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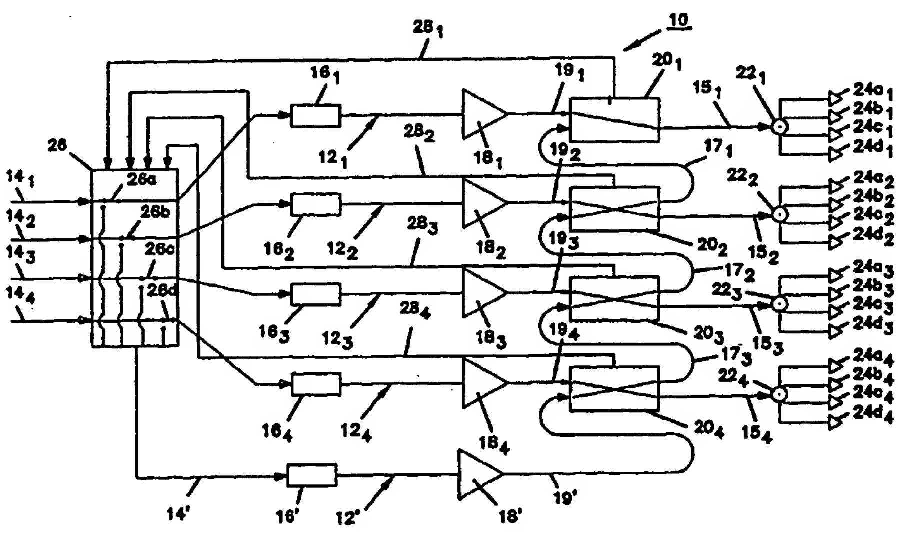

(57) Abstract

A telecommunication network uses a single backup signal transmission path to provide a backup in the event of failure of any one of a plurality of primary signal transmission paths. Both the primary signal transmission paths and the backup signal transmission path include electrical signal paths and a converter for converting the electrical signal to an optical signal path. A plurality of fiber optic switches direct a fiber optic signal from the backup transmission path to an output of a primary signal transmission path which is subject to an error detection. Simultaneously, an electrical switch redirects the incoming electrical signal of the primary signal transmission path to the backup signal transmission path.

MULTIPLE-LINE PROCTECTION FOR TELECOMMUNICATIONS NETWORK

I. BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to fiber optic transmission networks, and more particularly to such networks for use in the CATV industry. The invention pertains to a backup transmission path to be used in the event of an error in one of a plurality of primary signal transmission paths.

2. Prior Art

In a CATV network, a plurality of signal transmission paths distribute a signal from a source to a plurality of distribution points. Frequently, and particularly at the so-called "head end" of a CATV system, a plurality of radio-frequency (RF) signal paths direct a signal from a plurality of associated sources for eventual distribution to a plurality of distribution signal paths.

The primary signal transmission paths commonly include an RF signal path carried on coaxial cables and a subsequent conversion of the RF signal to an optical signal carried on fiber optic cables. The converted signal is then split into a plurality of optical signals carried on a plurality of distribution optical fibers. The primary signal path will include numerous circuit components, including a converter for converting the RF signal to an optical signal. Also, the circuit components commonly include an amplifier (such as an erbium-doped-fiber-amplifier -- EDFA) for amplifying the optical signals.

Reliability is an important design consideration in a CATV network. For example, an error can occur in a primary signal transmission. Such an error may be broadly defined to include any interruption in the signal or any unacceptable degradation of the signal. The error can be attributed to a variety of factors including damage to a fiber optic conductor or a malfunction of an RF-optic converter or EDFA. Such errors result in service interruption or poor quality service to a wide variety of subscribers who receive a signal from a plurality of distribution signal paths which are split off of the primary signal transmission path. Therefore, an error in a primary signal transmission path can result in interruption or degradation of service to a very large number of subscribers.

Since such an interruption or degradation is unacceptable in a CATV system, backup signal transmission paths are used in the event an error is detected in

a primary signal transmission path. Commonly, a prior art backup signal transmission path will include duplicate equipment (such as duplicate RF-optic converters and duplicate EDFAs) connected in parallel to the primary signal transmission path. A switch is used to switch the signal path from the primary signal transmission path to the backup signal transmission path in the event an error is detected in the primary signal transmission path. Such a switch may be a commonly used A-B fiber optic switch to switch the distribution signal paths from connection to the primary signal transmission path to the backup signal transmission path in the event of a detected error. Equipment for detecting errors and operating switches in response to detected errors are well known.

In the prior art backup signal transmission path described above, each primary signal transmission path has a dedicated backup signal transmission path. As a result, in networks having numerous primary signal transmission paths, numerous backup signal transmission paths are used. Such a network design is expensive since it requires duplicate RF-optic converters and duplicate EDFA amplifiers for each primary signal transmission path. Such equipment is very expensive and it is unfortunate that a large capital outlay must be expended for equipment intended to be idle during normal operations and intended to be used only in the rare event of an error detected on a primary signal transmission path.

Even though an error on a primary signal transmission path is a low-probability event, the consequences of such an error (disruption or unacceptable degradation of service to numerous subscribers) warrants the presence of a backup signal transmission path. Since the probability of an error in a primary signal transmission path is low, the probability of simultaneous errors in more than one primary signal transmission path is extremely low. As a result, a single backup signal transmission path could be used as a backup to numerous primary signal transmission paths. It is an object of the present invention to provide for a fiber optic transmission network having a plurality of primary signal transmission paths supported by a single backup signal transmission path. It is also an object of the present invention to provide such a backup signal transmission path with a network design which is of low cost and susceptible to fast operation to switch from a primary signal transmission path to the backup signal transmission path.

II. SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, a fiber optic transmission network includes a plurality of primary signal transmission paths. Each of the primary signal transmission paths includes an electrical signal path and

circuit components for converting a signal from the electrical signal path to an optical signal on a fiber optic path. The optical signal is passed to a distribution fiber path for eventual distribution to end users. The network includes a backup signal transmission path having circuit components including a converter for receiving an electrical signal from any one of the electrical signal paths of the primary signal transmission paths and converting the electrical signal to an optical signal on a backup fiber optic path. An electrical switch switches a selected one of the electrical signal paths to the backup signal transmission path in the event of a detected error. An optical switching circuit disconnects a distribution fiber path associated with the switched electrical signal path and connects the associated distribution fiber path to the backup fiber optic path.

III. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a telecommunications network having four primary signal transmission paths and single backup signal transmission path according to the present invention and showing signal paths when no error is detected along any of the primary signal transmission paths;

FIG. 2 is the view of FIG. 1 showing signal paths when an error is detected on a first of the plurality of primary signal transmission paths;

FIG. 3 is the view of FIG. 1 showing signal paths when an error is detected in a second of the primary signal transmission paths;

FIG. 4 is the view of FIG. 1 showing circuit paths when an error is detected in a third of the primary signal transmission paths;

FIG. 5 is the view of FIG. 1 showing signal paths when an error is detected in a fourth of the primary signal transmission paths;

FIG. 6 is a more detailed schematic view of a two-by-two switching component for use in the network of the present invention and with the switch of the switching component shown in a normal mode;

FIG. 7 is the view of FIG. 6 with the switch shown in a switched mode;

FIG. 8 is a more detailed schematic view of a one-by-two switching component for use in the network of the present invention and with a switch shown in a normal mode of operation; and

FIG. 9 is the view of FIG. 8 with the switch shown in a switched mode of operation.

IV. DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the various drawing figures in which identical elements are numbered identically throughout, a description of the preferred embodiment of the present invention will now provided.

FIG. 1 schematically illustrates a CATV network 10 as including four primary signal transmission paths 12_1 - 12_4. It will be appreciated that the illustration of four primary signal transmission paths is done for the purpose of illustrating the invention and such a network 10 may include more or less of such paths. The network 10 includes a single backup signal transmission line 12'.

Each of the primary paths 12_1-12_4 includes an electrical (radio frequency) signal path 14_1-14_4. Connected in series with the electrical signal paths 14_1-14_4 are converters 16_1-16_4 for receiving an electrical signal from the RF paths 14_1-14_4 and converting the electrical signal to an optical signal carried on a fiber optic path 19_1-19_4. The fiber optic paths 19_1-19_4 each include EDFA amplifiers 18_1-18_4 for amplifying the optical signal carried on the paths 19_1-19_4.

Each of the primary transmission paths 12_1-12_4 includes a fiber optic switch component 20_1-20_4 and a distribution fiber path 15_1-15_4. The distribution fiber path 15_1-15_4 is connected to a fiber optic splitter 22_1-22_4 for splitting an optical signal on distribution path 15_1-15_4 into a plurality of branch fiber optic paths $24a_1$-$24d_1$, $24a_2$-$24d_2$, $24a_3$-$24d_3$ and $24a_4$-$24d_4$.

Each of the RF signal paths 14_1-14_4 passes through a radio frequency switch 26 having internal switching components 26a, 26b, 26c, and 26d which, in a normal mode (illustrated in FIG. 1), pass a signal uninterrupted to an associated converter 16_1-16_4. Each of the switching mechanisms 26a-26d is selectively and individually switchable to a switched position for directing a selected one of the signals on the RF paths 14_1-14_4 to the backup signal transmission path 12'. The backup signal transmission path 12' includes an RF signal path 14' connected to a fiber optic converter 16' which converts the electrical signal to a fiber optic signal carried on a backup fiber optic path 19'. An EDFA amplifier 18' is associated with the fiber optic path 19'.

For purposes that will be more fully discussed, each of the switches 20_1-20_4 has an associated feedback line 28_1-28_4 to provide a signal to the RF switch 26 in response to the presence or absence of an error on the primary signal path 12_1 - 12_4.

The signal components 20_2-20_4 are identical switching components containing two-by-two optical switches. For reasons that will be apparent, switching component 20_1 contains a one-by-two optical switch. Since primary signal

transmission path 12_1 is identical in all respects to paths 12_2-12_4 but for switch 20_1, path 12_1 may conveniently be referred to as a terminal primary signal transmission path indicating that it is the last primary signal transmission path 12_1 having its switch 20_1, arranged in series with switches 20_2-20_4 from the backup signal transmission path 12' as will be described.

A two-by-two switching component 20_2 is more fully schematically illustrated in FIGS. 6 and 7. It will be appreciated that switching components 20_3 and 20_4 are identical to component 20_2 and do not require separate description. Subscript designation (e.g., 28_2, 60_2) will be used to reference components of a specifically identified switch 20_2. When collectively or generally referencing to components of switch 20_2-20_4, the subscripts will be omitted in this description (e.g., 28, 60).

The switching component 20_2 includes a switch housing 50_2 and an error detector/controller 60_2. The switch housing 50_2 contains an internal splitter 52_2 for splitting a signal carried on the fiber optic path 19_2 with a small portion of this signal passed to monitor signal path 54_2. The remainder of the signal from path 19_2 is passed to a primary input $56a_2$ of a two-by-two fiber optic switch 56_2. A secondary input $56b_2$ of switch 56_2 is connected to a bypass fiber optic cable 17_2.

A primary output $56a'_2$ of switch 56_2 is connected to the distribution fiber path 15_2. The secondary output $56b'_2$ of switch 56_2 is connected to a bypass fiber optic cable 17_1. The monitor fiber 54_2 is passed to the controller 60_2 which monitors the presence and integrity of the signal on fiber 54_2.

In the event of an interruption or unacceptable degradation of the signal, the controller 60_2 transmits an error signal along feedback lines 28_2 and $28a_2$. In the absence of such detected error or unacceptable degradation, the controller 60_2 transmits a no-error signal along feedback lines 28_2, $28a_2$.

FIG. 6 illustrates the switching component 20_2 in a normal mode of operation where the switch 56_2 directs a signal from the primary input $56a_2$ to the primary output $56a'_2$ and further directs a signal from the secondary input $56b_2$ to the secondary output $56b'_2$. FIG. 7 illustrates the switching component 20_2 in a switched mode where the primary input $56a_2$ is connected to the secondary output $56b'_2$ and the secondary input $56b_2$ is connected to the primary output $56a'_2$.

As mentioned, and for reasons that will become apparent, switching component 20_1 differs from component 20_2 only in that the internal switch 56_1 is a one-by-two switch with a primary input $56a_1$ normally connected to a primary output $56a'_1$. In such a mode, the secondary input $56b_1$ is terminated. All other components of switch component 20_1 are identical to those of switch component 20_2 and are identically numbered except for the addition of a distinguishing subscript. FIG. 9

illustrates switching component 20_1 in a switched mode where the primary input $56a_1$ is terminated and the secondary input $56b_1$ is connected to the primary output $56a'_1$.

As illustrated in the drawings, each of the fiber optic paths 19_1-19_4 of the primary signal transmission paths 12_1 - 12_4 are connected to the primary inputs 56a of each of the switching components 20_1-20_4. The distribution fiber paths 15_1-15_4 are connected to the primary outputs 56a' of each of the switching components 20_1-20_4.

The backup fiber optic path 19' is connected to the secondary input $56b_4$ of switching component 20_4. Bypass fiber optic cable 17_3 connects the secondary output $56b'_4$ of switching component 20_4 to the secondary input $56b_3$ of switching component 20_3.

Bypass fiber optic cable 17_2 connects the secondary output $56b'_3$ of switching component 20_3 to the secondary input $56b_2$ of switching component 20_2. Similarly, fiber optic cable 17_1 connects the secondary output $56b'_2$ of switching component 20_2 with the secondary input $56b_1$ of switching component 20_1.

With the network thus described, a plurality of sources (not shown) transmit a plurality of RF signals across individual lines 14_1-14_4. In the absence of an error, a no-error mode signal is passed over feedback 28_1-28_4. Therefore, switches 26a-26d are in their normal mode illustrated in FIG. 1 such that the signals on lines 14_1-14_4 are passed to their associated converters 16_1-16_4 for conversion to optical signals on fiber optic cables 19_1-19_4. The fiber optic signals are amplified by amplifiers 18_1-18_4.

In addition to controlling RF switch 26, the controllers 60 control switching components 20_1-20_4. Namely, while a no-error signal is passed along lines 28_1-28_4, a no-error signal is also passed along feedback lines 28a such as lines $28a_1$ and $28a_2$ in FIGS. 7-9 to hold switches 20_1-20_4 in their normal unswitched mode of operation. With each of the switches 20_1-20_4 in the normal mode of operation, the signals on fiber optic paths 19_1-19_4 are passed to associated distribution fibers 15_1-15_4 for ultimate splitting among the associated branch fibers $24a_1$-$24d_1$, $24a_2$-$24d_2$, $24a_3$-$24d_3$, and $24a_4$-$24d_4$.

While the signals are passing through the unswitched switching components 20_1-20_4, small portions of the signals are being passed by the splitters 52 to the controllers 60. As long as no signal interruption or unacceptable signal degradation is determined by the controller 60, the no-error signal is passed by the feedback lines 28, 28a to the RF switch 26 and fiber optic switches 20_1-20_4.

FIG. 2 illustrates a system response in the event an error is detected on the primary transmission line 12_1. In such an event, the controller 60_1 transmits

an error signal across feedback lines 28_1 and $28a_1$ to the RF switch 26 and the fiber optic switch 56_1. In response to an error signal on line 28_1, the RF switch 26 is activated such that internal switch 26a is switched to redirect the RF signal from RF conductor 14_1 to the RF conductor 14' of the backup transmission circuit 12'. Simultaneously, an error signal is sent across line $28a_1$ to switch 56_1 causing the internal switch 56_1 to switch to the switched mode illustrated in FIG. 9. Switches 20_2-20_4 remain in the normal, unswitched mode. As a result of this operation, the signal on RF conductor 14_1 completely bypasses the primary transmission path 12_1 and is redirected to the backup transmission path 12'. On backup path 12', the signal is converted to a fiber optic signal at converter 16' and subsequently amplified by amplifier 18'. The amplified backup signal is passed along the backup fiber optic path 19' to the secondary input $56b_4$ of switch 20_4. Since switches 20_2-20_4 remain in the unswitched mode, the signal passes through the switches 20_2-20_4 via fiber optic cables 17_2 and 17_3. From switch 20_2, the backup signal is passed through fiber optic cable 17_1 to the secondary input $56b_1$ of switch 20_1. Since switch 20_1 has been put in the switched mode of FIG. 9, the signal is passed to distribution fiber 15_1. Therefore, in the event of an error on line 12_1, the RF signal on path 14_1 passes through the backup signal transmission path 12' and is subject to the same fiber optic conversion and amplification functions normally performed by converter 16_1 and amplifier 18_1 and now performed by converters 16' and amplifier 18'. The converted and amplified signal is then distributed to distribution fiber 15_1. As a result, subscribers served by branch fibers $24a_1$-$24d_1$ receive a signal as if no error or degradation had occurred on signal transmission line 12_1. In the event the cause of the error is corrected on primary transmission line 12_1, the switch 20_1 reverts to its normal mode of operation illustrated in FIG. 8 and switch 26a also reverts to normal mode operation such that the signal from RF line 14_1 passes through transmission line 12_1 and avoids the backup signal path 12'.

FIG. 3 illustrates operation of the network in the event an error occurs on line 12_2. In such an event, the error is detected by controller 60_2 which sends an error message across feedback lines 28_2 and $28a_2$. In response to the error message on feedback line 28_2, the RF switch 26 switches internal switch 26b for the RF signal on conductor 14_2 to bypass the primary transmission path 12_2 and be redirected to the backup transmission path 12'.

In response to the error signal on feedback line $28a_2$, switch 20_2 switches to the switched mode of operation illustrated in FIG. 7 while switches 20_1 and 20_3, 20_4 remain in their unswitched, normal mode of operation. As a result, the signal on RF conductor 14_2 is converted and amplified by the backup transmission path 12' and the converted and amplified signal flows through switches 20_3 and 20_4

to the secondary input $56b_2$ of switch 20_2. Since switch 20_2 has been switched, the secondary input $56b_2$ is connected to the distribution fiber 15_2 so the signal passes to the subscribers on branch lines $24a_2$-$24d_2$. Again, once the error on transmission path 12_2 has been corrected, switches 26b and 20_2 revert to the normal mode of operation illustrated in FIGS. 1 and 6.

FIGS. 4 and 5 illustrate operation of the network 10 in the event an error is detected on primary transmission lines 12_3 and 12_4, respectively. The mode of operation is identical to that illustrated in FIG. 3. Namely, in the event of an error on line 12_3, switches 26c and 20_3 are switched from their normal mode of operation to their switched mode of operation. As a result, the signal on line 14_3 passes through the backup signal transmission path 12' and is converted and amplified and directed to distribution path 15_3. Similarly, FIG. 5 illustrates that an error in primary transmission line 12_4 results in switches 26d, 20_4 being switched with the signal on line 14_4, is passed through the backup transmission path 12', and converted and amplified and redirected to path 15_4.

With the present invention, a single backup transmission path 12' serves as a backup in the event of an error detected on any one of a plurality of primary transmission signal paths 12_1-12_4. The present invention can provide a backup to only one of the plurality of primary transmission signal paths 12_1-12_4 at any one time. However, an error in any one of such paths 12_1-12_4 is a very low probability and multiple errors on multiple paths are, accordingly, extremely remote possibilities.

The signal from the backup transmission path 12' passes through multiple switches (for example, switches 20_2-20_4) before finally passing to switch 20_1 in the event of an error on line 12_1. Since fiber optic switches such as switches 20_2-20_4 can result in signal loss, amplifier 18' is preferably a higher gain amplifier than amplifiers 18_1-18_4 in order to make up for signal losses of a signal passing through any of fiber optic switching components 20_1-20_4. Commonly, amplifiers 18_1-18_4 are 17 dBm amplifiers and switches such as 20_2-20_4 are about 0.2 dBm loss switches. Commercially available EDFA amplifiers are available at 24 dBm gain (and higher). Therefore, with amplifier 18' selected as a 24 dBm gain amplifier and with amplifiers 18_1-18_4 selected as 17 dBm amplifiers, the combined loss through switches 20_2-20_4 should not exceed 7 dBm. However, since switches 20_2-20_4 are available at 0.2 dBm loss, the theoretical maximum number of primary lines which can be served by backup transmission path 12' will be thirty-five primary transmission paths 12_1 - 12_4. It will be appreciated that this represents a theoretical maximum. As the number of primary transmission paths 12_1 - 12_4 increases with the paths being served by a single backup transmission path 12', the probability of

having two primary transmission paths 12_1 - 12_4 in an error mode increases. As a result, the number of primary transmission paths 12_1 - 12_4 which can be served by a single backup path 12' is also a function of a system designer's risk aversion to the remote probability that more than one primary signal transmission path 12_1 - 12_4 will be under an error condition at any one time.

With the present invention, the network 10 has dramatically reduced costs compared with a prior art network design where each primary transmission paths had a dedicated backup transmission path. The prior art system virtually doubles the amount of equipment and expense required over a system that had no backup transmission paths. The expense is particularly great with respect to EDFA amplifiers which are very expensive items. Instead of doubling expense, the present invention adds only a single backup transmission path 12' to serve multiple primary transmission paths 12_1 - 12_4. The network 10 retains high reliability and high quality by switching not only the optical signals but also RF sources. The system 10 can achieve fast switching operation by performing one-step switching, no matter which primary line is out of service. Further, the present invention achieves the desired benefits with decreased optical light attenuation by avoiding excessive use of splitters. Also, once the system is in place for a given number of primary transmission lines, it can be readily expanded to have the single backup transmission 12' service additional primary transmission paths. Finally, all components of the network 10 (such as switches 20_1-20_4 with monitor capabilities, a controller 60 and RF switches 26) are commercially available items making the present invention susceptible to rapid implementation.

Having disclosed the present invention in a preferred embodiment, it will be appreciated that modifications and equivalents of the disclosed concepts may readily occur to one of ordinary skill in the art. It is intended that such modifications and equivalents shall be included within the scope of the claims which are appended hereto.

What is claimed is:

1. A fiber optic transmission network comprising:

a plurality of primary signal transmission paths each having:

an electrical signal path;

circuit components including a converter for receiving an electrical signal from said electrical signal path and converting said electrical signal to an optic signal on a fiber optic path;

a fiber optic switch component having:

primary and secondary inputs;

primary and secondary outputs;

an optical switch for selectively switching between a primary mode with said primary input and output connected and a secondary mode with said secondary input and output connected;

said primary input connected to said fiber optic path and said primary output connected to a distribution fiber path;

a backup signal transmission path having circuit components including a converter for receiving an electrical signal from any one of said electrical signal paths as an input and converting said signal to an optic signal on a backup fiber optic path;

said backup fiber optic path connected to a secondary input of a selected one of said fiber optic switch components;

individual ones of said secondary outputs of said fiber optic switch components connected to secondary inputs of individual ones of said fiber optic switch components;

an electrical switch for switching a selected one of said electrical signal paths to said backup signal transmission path;

a controller for detecting an error in an individual one of said primary signal transmission paths and, in response to said detection:

shifting said optical switch of said individual one from said primary mode to said secondary mode; and

operating said electrical switch to switch said electrical signal path of said individual one to said backup signal transmission path.

2. A fiber optic transmission network according to claim 1 further comprising:

a terminal primary signal transmission path having:

an electrical signal path;

circuit components including a converter for receiving a signal from said electrical signal path and converting said signal to an optic signal on a fiber optic path;

a fiber optic switch components having:

primary and secondary inputs;

a primary output;

an optical switch for selectively switching between a primary mode with said primary input and output connected and a secondary mode with said secondary input and said primary output connected;

said primary input connected to said fiber optic path and said primary output connected to a distribution fiber path;

said secondary input connected to a secondary output of one of said optical switch of said primary signal transmission paths.

3. A fiber optic transmission network comprising:

a plurality of primary signal transmission paths each having:

an electrical signal path;

circuit components including a converter for receiving an electrical signal from said electrical signal path and converting said electrical signal to an optic signal on a fiber optic path;

a distribution fiber path;

a backup signal transmission path having circuit components including a converter for receiving an electrical signal from any one of said electrical signal paths as an input and converting said electrical signal to an optic signal on a backup fiber optic path;

an electrical switch for switching a selected one of said electrical signal paths to said backup signal transmission path;

an optical switching circuit for disconnecting a selected one of said distribution fiber paths and connecting said selected one to said backup fiber optic path;

a controller for detecting an error in an individual one of said primary signal transmission paths and, in response to said detection:

operating said optical switching circuit to disconnect said distribution fiber path of said individual one and connecting said distribution fiber path of said individual one to said backup fiber optic path; and

operating said radio frequency switch to switch said radio frequency path of said individual one to said backup signal transmission path.

4. A fiber optic transmission network according to claim 3 wherein:

said optical switching circuit comprises a plurality of fiber optic switch components associated with each of said primary signal paths with said fiber optic switch components having:

primary and secondary inputs;

primary and secondary outputs;

an optical switch for selectively switching between a primary mode with said primary input and output connected and a secondary mode with said secondary input and output connected;

said primary input connected to said fiber optic path and said primary output connected to said distribution fiber path;

said fiber optic path of said backup signal transmission path connected to a secondary input of a selected one of said fiber optic switch components;

individual ones of said secondary outputs of said fiber optic switch components connected to secondary inputs of individual ones of said fiber optic switch components;

said controller operating said optical switching circuit by shifting said optical switch of said individual one from said primary mode to said secondary mode.

5. A fiber optic transmission network according to claim 3 wherein said optical switching circuit comprises a plurality of fiber optic switches each associated with an individual one of said fiber optic paths of said primary signal transmission paths;

said fiber optic switches having normal paths for a signal on an associated primary signal transmission path to pass to an associated distribution path;

said fiber optic switches further having switched paths for said switch to receive a fiber optic signal from a different one of said switches and pass said signal to said associated distribution path.

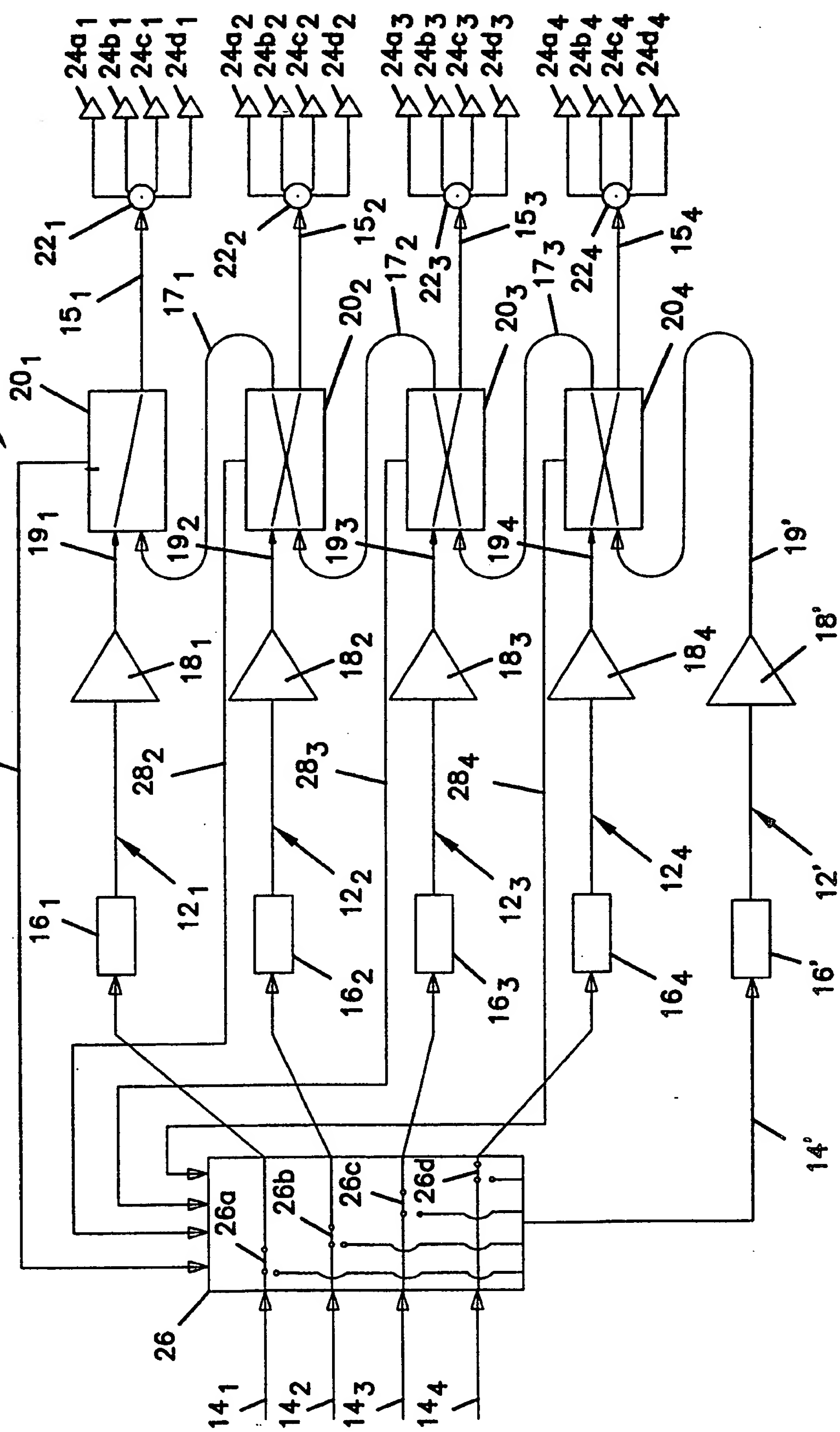
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FIG. 1

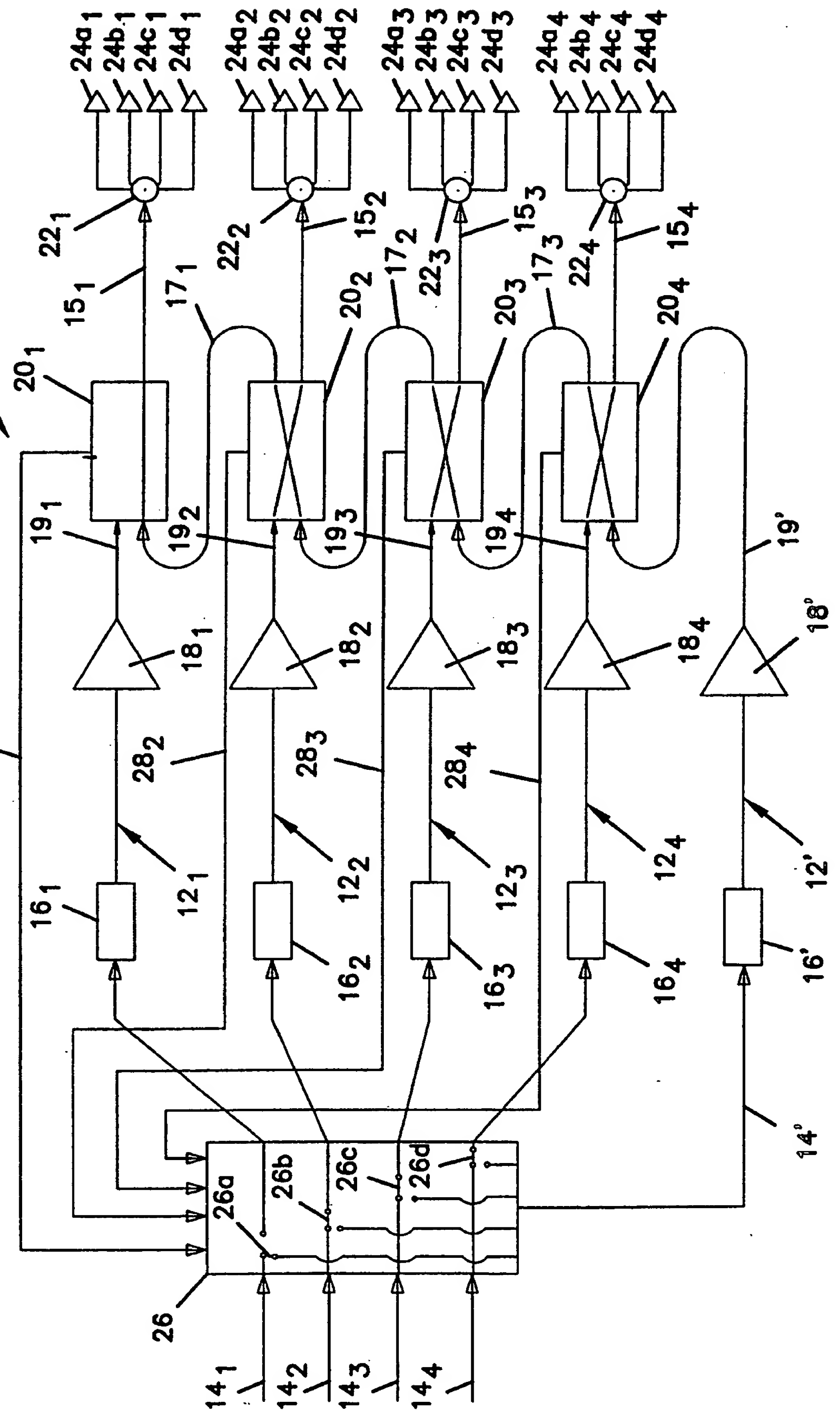
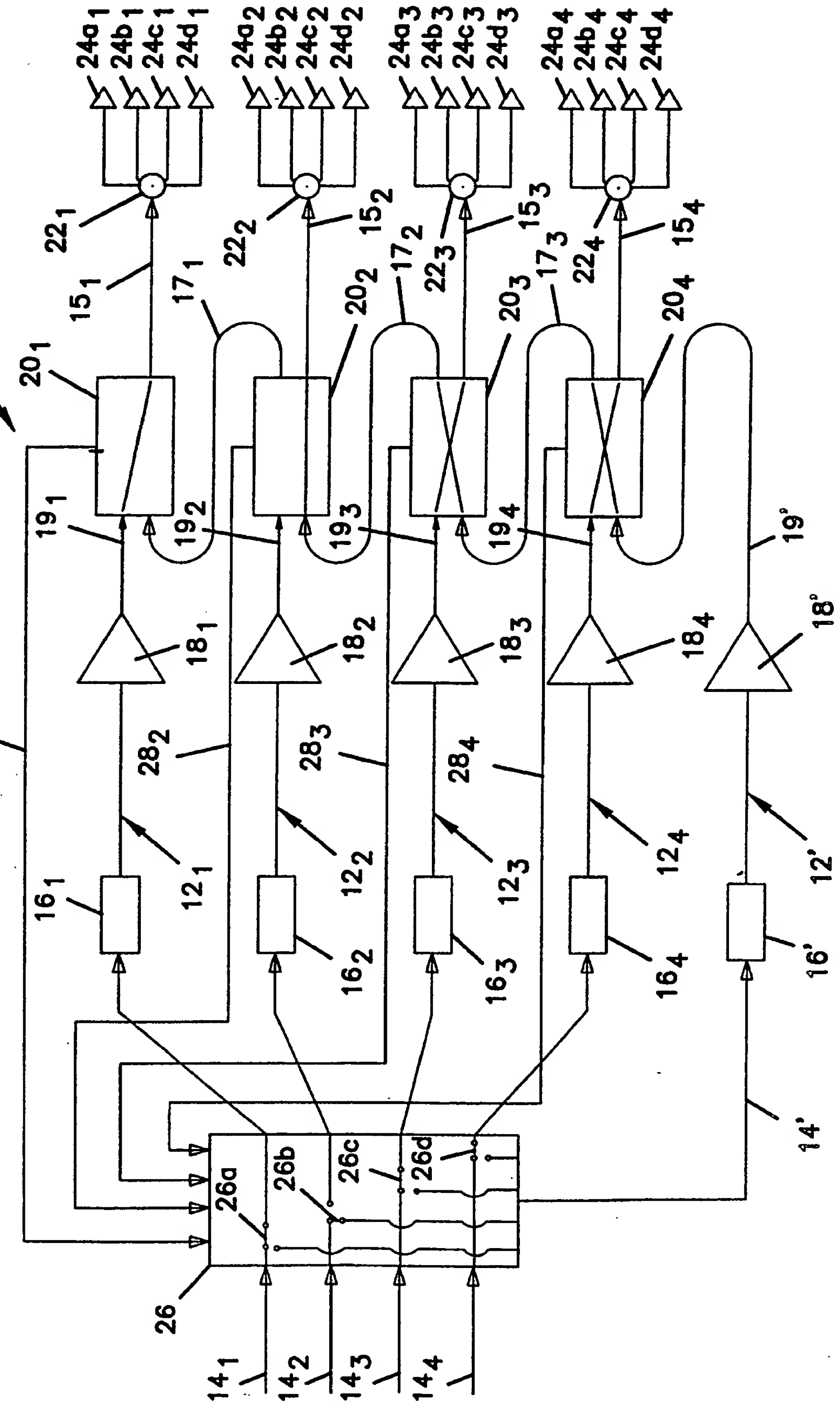


FIG. 2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28_1 28_2 28_3 28_4
12_1 12_2 12_3 12_4 12'
16_1 16_2 16_3 16_4 16'
14'
26a 26b 26c 26d
26
14_1 14_2 14_3 14_4

FIG. 3

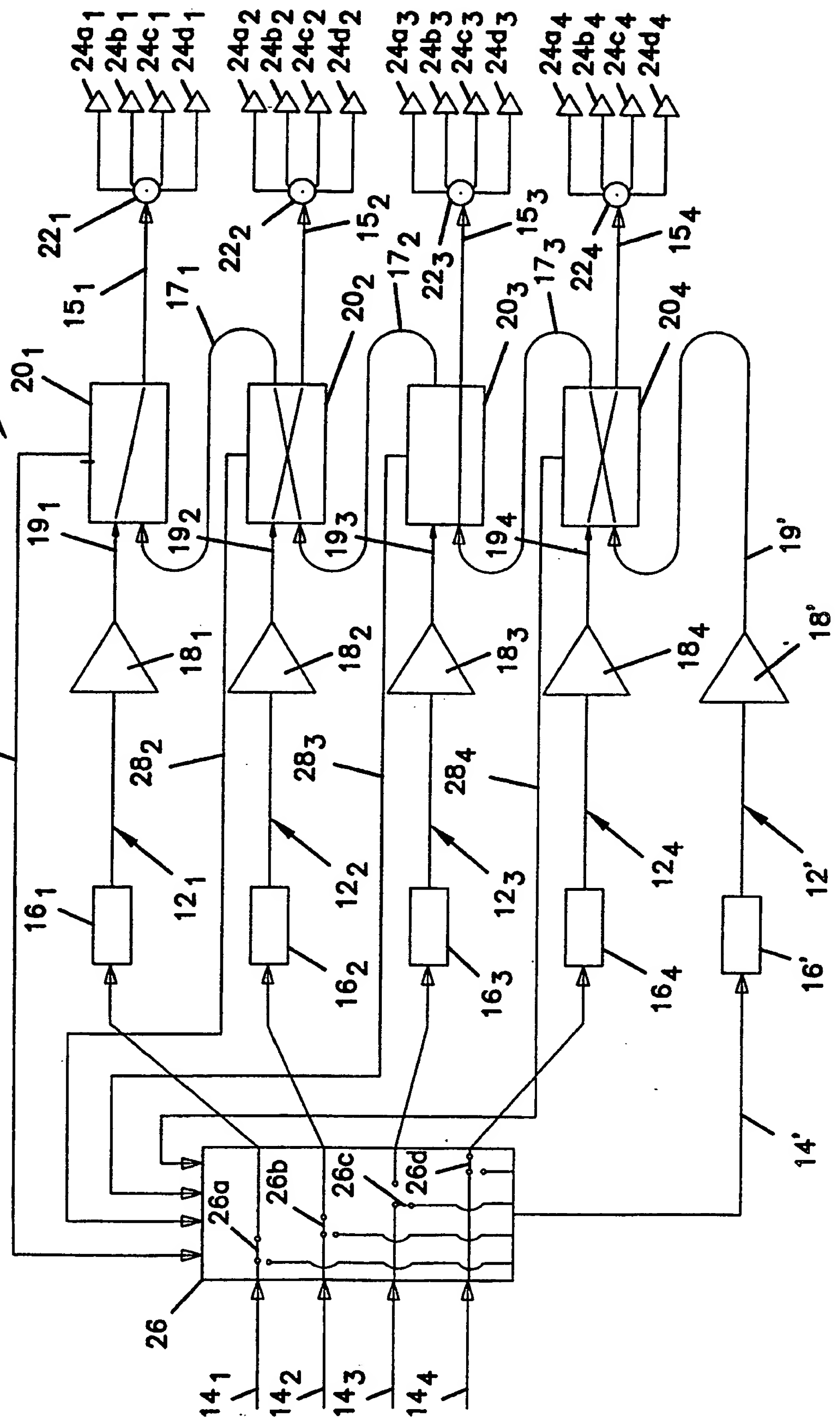

10
24a1 24b1 24c1 24d1
24a2 24b2 24c2 24d2
24a3 24b3 24c3 24d3
24a4 24b4 24c4 24d4
22₁ 22₂ 22₃ 22₄
15₁ 15₂ 15₃ 15₄
17₁ 17₂ 17₃
20₁ 20₂ 20₃ 20₄
19₁ 19₂ 19₃ 19₄ 19'
18₁ 18₂ 18₃ 18₄ 18'
28₁ 28₂ 28₃ 28₄
12₁ 12₂ 12₃ 12₄ 12'
16₁ 16₂ 16₃ 16₄ 16'
14'
26a 26b 26c 26d
26
14₁ 14₂ 14₃ 14₄

FIG. 4

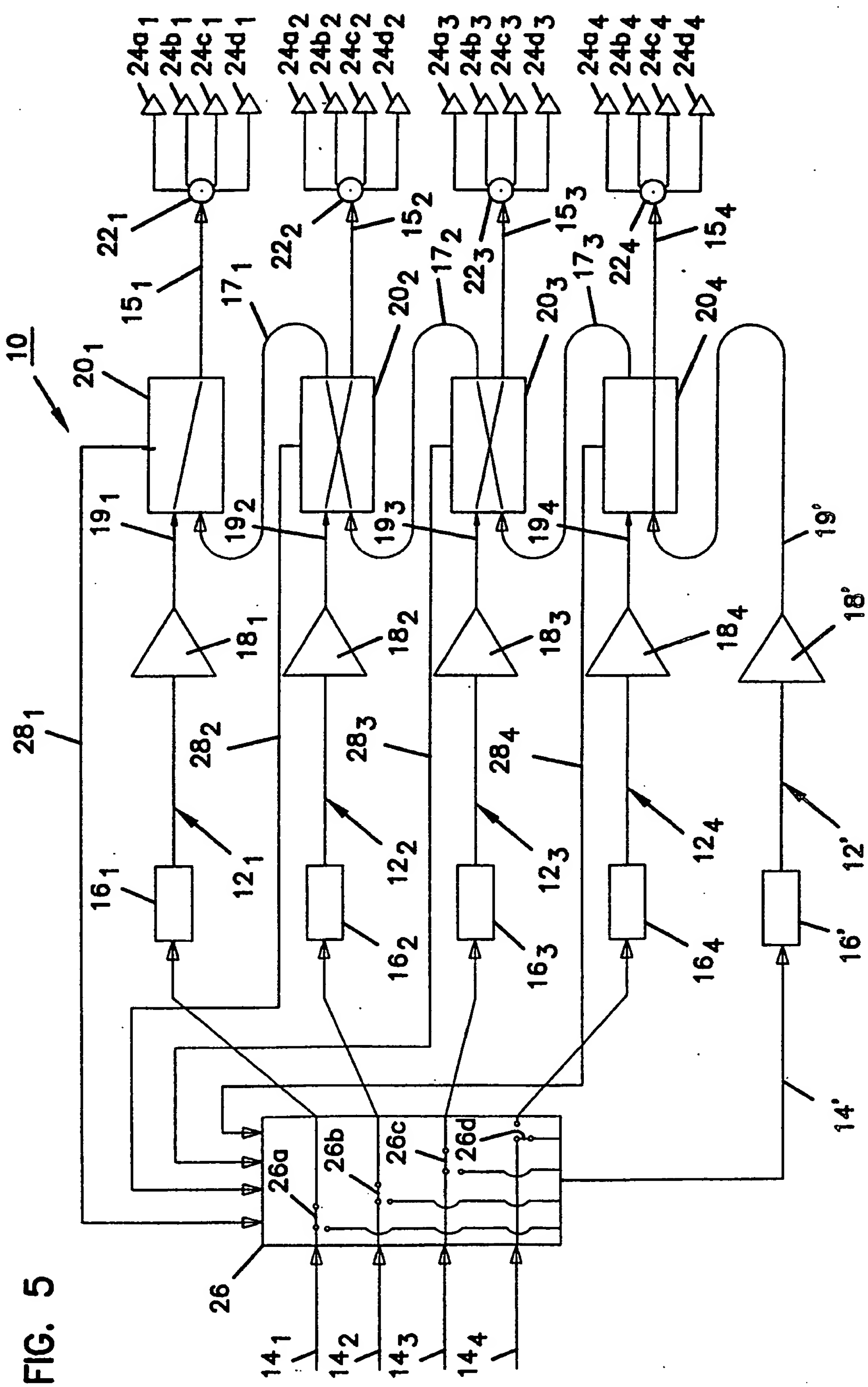


FIG. 5

FIG. 6

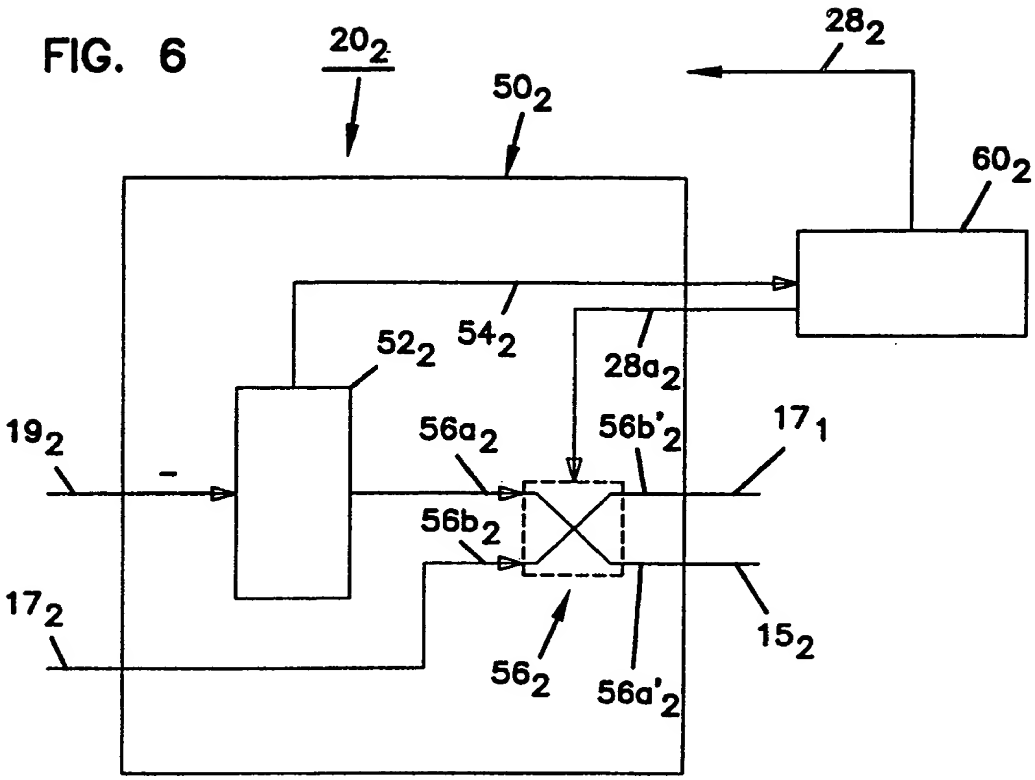

20_2
28_2
50_2
60_2
52_2
54_2
$28a_2$
19_2
$56a_2$
$56b'_2$
17_1
$56b_2$
17_2
15_2
56_2
$56a'_2$

FIG. 7

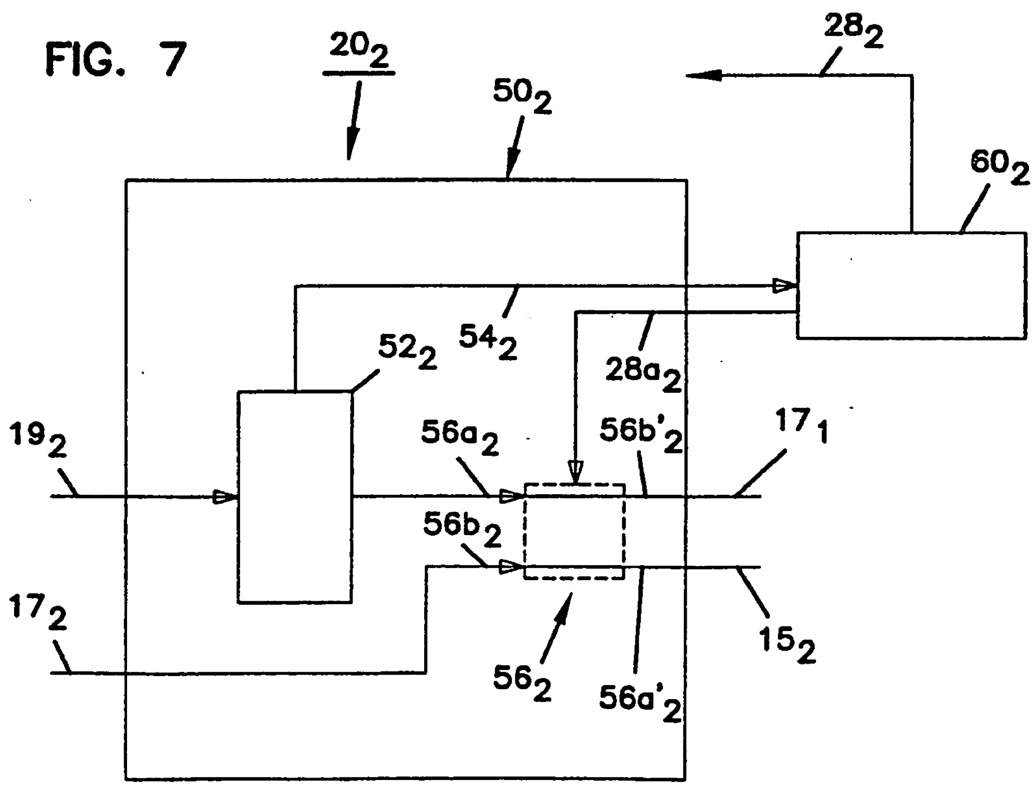

20_2
28_2
50_2
60_2
52_2
54_2
$28a_2$
19_2
$56a_2$
$56b'_2$
17_1
$56b_2$
17_2
15_2
56_2
$56a'_2$

FIG. 8

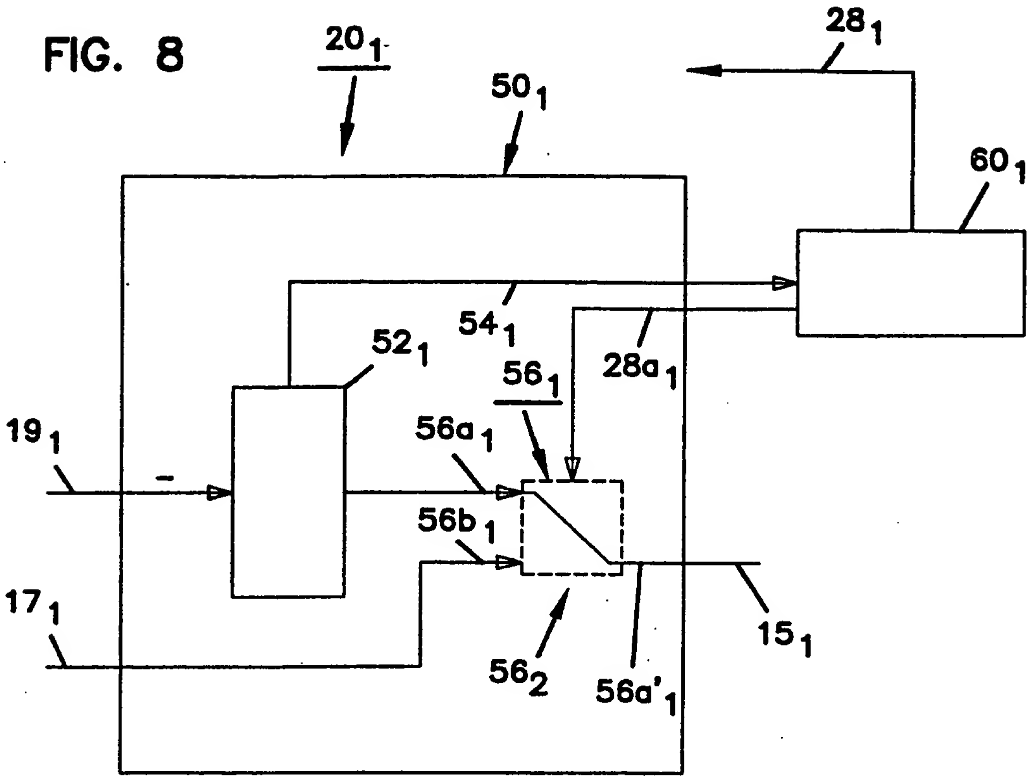
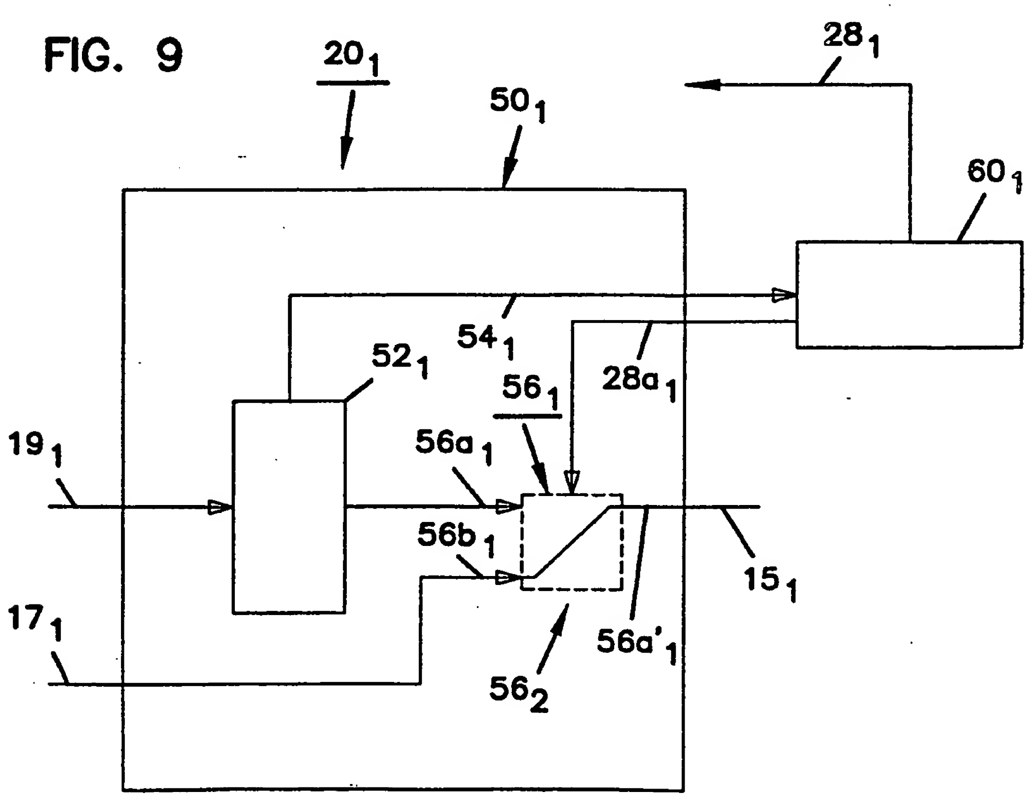

20 1
50 1
28 1
60 1
54 1
28a 1
52 1
56 1
19 1
56a 1
56b 1
17 1
15 1
56 2
56a' 1

FIG. 9


20 1
50 1
28 1
60 1
54 1
28a 1
52 1
56 1
19 1
56a 1
56b 1
15 1
17 1
56a' 1
56 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/14924

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B10/00 H04N7/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 233 851 A (PLESSEY TELECOMM) 16 January 1991 see page 5, line 4 - line 19 see page 6, line 22 - page 7, line 25 see page 13, line 6 - page 14, line 6 see figures 2,3 ---	1-5
A	POULIN C: "SINGLE MODE OPTICAL FIBRE CATV SYSTEM" COMMUTATION ET TRANSMISSION, vol. 17, no. 1, 1 January 1995, pages 53-60, XP000490027 paris,fr see page 55, right-hand column, line 1 - page 56, right-hand column, line 9 see figure 3 --- -/--	3-5

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 October 1998	23/10/1998

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 617 525 A (FURUKAWA ELECTRIC CO LTD) 28 September 1994 see page 4, column 3, line 40 - page 5, column 6, line 18 see figures 1-3 ---	1-5
A	DE 36 44 802 A (SCHMITT HANS JUERGEN ;SEIDENBERG JUERGEN DIPL ING (DE)) 14 July 1988 -----	

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/US 98/14924

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EP 0617525 A	28-09-1994	CA 2125692 A WO 9409575 A	28-04-1994 28-04-1994
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